HOUSING FOR LED-CHIP AND LIGHT SOURCE

The present invention relates to a housing for an LED-chip, a light source with an array of LED-chips, a housing for a light source and a method for manufacturing a light source.

Light sources are known from the documents WO 99/41785 and WO 03/023857, which are constructed in a panel-like manner with an array of unhoused LEDs as light producing elements, wherein subgroups of LEDs capable of functioning on their own are formed. The light sources may be separated into units which are capable of functioning and which in each case comprise one sub-group.

A panel-like carrier structure for LED-chips or the housing of an LED-chip has the fulfil the following functions:

- the LED-chip must be able to be fastened on a suitable element and electrically contacted,
- the chip and its electrical contactings must be permanently protected from harmful, mechanical and chemical environmental influences,
- the light emitted by the chip, as a rule with a large spatial angle range, as a rule must be concentrated into a smaller spatial angle range,
- and additionally, it is becoming increasingly important to ensure an optimal thermal transport from the chip to the housing surface. This last point becomes very important when either a large number of individually housed LED-chips are to be unified on an as small as possible surface, or if so-called power chips are applied, i.e. chips which accommodate an electrical power of 1W, 5W or even more, and apart from a correspondingly large light emission also produce much waste heat.
- In many cases, it is also important for the light radiated away from the LED-chip at a certain wavelength - thus for example in the UV or in the blue range - at least partly, to be converted as a rule to larger wavelengths.

A very large quantity of constructions exist on the market and in patent literature, which solve the first four points of these set tasks to a greater or lesser extent. The last point will be dealt with further below.

The publication documents US2003058650, WO03069685, US20021755621 and US2001030866 published in the last 3 years are mentioned as a few examples of many.

Furthermore, the description of the construction of the so-called power LEDs of the company Lumineds marketed under the trade name Luxeon which may be called up via the internet (www.lumineds.com) is referred to.

Common to the mentioned and many other known constructions is the fact that the LED-chip is fastened on a carrier which per se or in combination with an additional body, acts as a more or less optimal heat sink.

Additionally common to the mentioned constructions is the fact that the necessary optical elements - and thus mostly essentially more that half the surface of the housing - consist of at least partly optically transparent plastic, by which means this part of the housing forming a significant part of the housing surface hinders rather than promotes the removal of heat.

An idea which partly overcomes this disadvantage is outlined in the mentioned publication document WO03069685, in that the applied optically transparent plastic is filled with optically transparent and relatively thermally conductive particles of diamond for example.

Within the context of light collimation and with respect to the constructions of known LED-lamps, it should be stated that the light collimation is carried out practically exclusively with dome-like, optically transparent plastic lenses. Proceeding from small LED-chips (size approx. 0.3x0.3), narrow collimation angles of less than ±20° are produced in this manner only with lens elements with dimensions in the magnitude of a diameter of 5 mm and a height of approx. 8 mm. For LED-chips of the size 1x1 mm, such lens elements of approx. 12 mm diameter and 15 mm height are necessary for an angle < ±20°

For very small lamps with small LED-chips, for example so-called SMD LED with a volume for example of 1.5 x 1.2 x 1.5 mm, a light collimation of ±40° at best is known.

However, LED-lamps which achieve a corresponding light collimation with smaller lamp volumes would be desirable within the context of a smaller space requirement and an improved ratio of surface area /volume and thus an improved heat removal.

The light sources known from the documents WO9941785 and WO03023857 have the disadvantage that on the one hand the heat removal is not optimal, and on the other hand that the LED-chip must be operated together in relatively large sub-groups, by which means also only relatively large units arise which as a whole may be cut out of the array.

It is the object of the invention to provide a housing for an LED-chip as well a light source as a - theoretically infinitely large - array of LED-chips, which overcomes the above mentioned disadvantages of existing housings. In particular, an optimised or maximised heat removal, preferably with a simultaneous reduction of the lamp volume required for a certain light collimation and/or with an as small as possible volume of the housing, and a good collimation of the light radiated from the LED-chip or LED-chips should be achieved.

In the case of the light source, it should preferably also be ensured that the smallest sub-unit which may be individually cut out and is capable of functioning alone consists exactly of a single housed LED-chip or of a commonly housed group of several LED-chips emitting in different spectral ranges. A further object relates to the wiring of the LED-chips. It should be made possible for the LED-chips to be able to be provided with as little wire bonds as possible, and despite this for the LED-chips of the functional sub-units to be able to be almost infinitely connected to one another, i.e. in series, parallel, series-parallel combined, etc..

These objects are achieved by the invention as is defined in the patent claims.

The housing according to the invention is suitable for individual LED-chips or several LED-chips which are arranged next to one another, for example emitting in different spectral ranges.

According to a first aspect of the invention, a maximal heat removal may be achieved by way of assembling the LED-chip with an essentially metallic connection into an essentially metallic housing (individual housing) or housing part (light source with an array of LEDs), and this housing or housing part on the one hand having an as large as possible surface area being in contact with the surrounding medium, for the heat transfer, and on the other hand having an as optimal as possible, thermally conductive path from the chip to this surface.

In the case of the light source, an array of LED-chips deposited on a carrier element and which is able to be cut up is present, as well as a concave-mirror-like or aperture-like optical element per LED-chip or unit of LED-chips which are arranged next to one another and which for example emit in different spectral ranges. A continuous, thermally conductive path in the context that each of the elements constituting this thermally conductive path is either completely metallic or plastic filled with metal, exists from a fastening surface of the LED-chip or LED-chips to surfaces of the optical element open to the outside, and the mentioned elements in their sum form a continuous cooling body for the LED-chip.

The invention also relates to a housing for an array of LED-chips. A housing for an array of LED-chips here is a plate-like or strip-like, but possibly flexible carrier element with a plurality of optically effective, mechanically protecting elements which in each case are allocated to the LED-chip or a unit of a few LED-chips which are arranged next to one another and which for example emit in different spectral ranges, and surround these at least in a partly protecting manner.

"Essentially metallic" is to mean that corresponding material is either a metal or at least a plastic filled with metal particles. Preferably, the material as a whole consists of at least 50% (percentage by weight) of metal.

An as large as possible surface for the heat transfer to the surrounding medium, for starters, may firstly be achieved by not only using a good thermally conductive carrier for the LED-chip which acts as a heat sink, but also by way of an optically acting region also being at least partly metallic.

An optimal thermally conductive path is given when the ratio of local thermally conductive cross section to the local length of the thermally conductive path is as large as possible everywhere in the housing.

This, in the direct vicinity of the contact surface of the LED chip and carrier, may be achieved by way of the carrier being fully metallic and as thin as possible in the direct vicinity of the contact surface. By way of this, an extremely short thermally conductive path to the rear side of the metallic carrier, and thus an as high as possible temperature at the corresponding surface of the carrier is ensured, which in turn results in a high thermal emission to the surrounding medium.

On the other hand however, advantageously, a larger thermally conductive cross section is present towards the surface parts which are distanced further to the connection location between the LED-chip and the carrier, and this cross section where possible becomes larger with an increasing length of the thermally conductive path.

The apparent contradiction between an as thin as possible carrier and a large, thermally conductive cross section to distanced housing parts having an as large as possible surface is amazingly simple to solve in combination with a metallic, concave-mirror-like optical element.

For this, the construction of the housing may essentially have a metallic, thin carrier, onto which the LED-chip is deposited essentially with a metallic connection. For example, an essentially metallic optical element which acts as a concave mirror or aperture for the light of the

LED-chip, and which is connected essentially metallically firstly in a thick-walled manner and secondly in a large-surfaced manner to the mechanical carrier, is present around the LED-chip.

According to a preferred embodiment of the invention, the ideas are combined in a housing or a light source. Such a combination fulfils all demands which lead to an improved housing construction in the context of the invention.

The outlined idea further leads to additional, considerable advantages compared to conventional LED-housings and light sources. An essentially metallic, optical element completely surrounding the LED-chip and significantly rising above it in height simultaneously protects the chip and its electrical connections from any mechanical influences acting on the housing, such as pressure forces or shear forces and/or impacts for example.

Furthermore, the aperture-like or concave-mirror-like inner opening of the mentioned optical element may be filled at least partly or to just below the upper edge, with an optically transparent material, possibly acting as a lens-like element, which does not need to cure completely but for example may remain permanently elastic or which is not very stable with regard to mechanical loading. By way of this - without additional protective measures - materials such as transparent silicones or amorphous fluoro-polymers such as Teflon AF of the company Dupont may be applied for example. These materials not only have excellent optical properties, but apart from possibly achieving an optical effect, they also meet the purpose of such a filling, which lies in protecting the chip and its electrical connections from chemical environmental influences, i.e. from harmful gases such as for example oxygen or aggressive exhaust products, from water vapour and from water.

It is possible to further improve the capability of the heat removal of the outlined construction. This may for example be effected according to a first possibility by way of enlarging the outer surface of the thick-walled body acting as an aperture-like or concave-mirror-like element, for example by way of ribs.

A second, additional possibility is to fill the inner, aperture-like or concave-mirror-like surface with optically transparent material as little as possible - but as much as required for the mentioned chemical protection. By way of this, the surface area remaining free acts firstly as an additional heat transfer surface, and secondly the thermally conductive path through the optically transparent material is shortened.

A third additional possibility is to fill the poorly thermally conducting, optically transparent material with highly thermally conductive particles, which act in an optical manner as little as possible.

Such particles may for example be diamond particles of the magnitude of 1 to 100 μm, but may also be metallic particles whose diameter is smaller than the wavelength of the visible light.

According to a second aspect of the invention, one may achieve an equally good light collimation with a reduced volume of the optical elements by way of not using the known dome-like lens elements, but concave-mirror-like optical elements which significantly exceed the dimensions of the LED-chip in diameter and height. Of course, such concave-mirror-like elements may be metallic and thus correspond to the first aspect. A possible further improvement in this context is possible in that these concave mirror-like optical elements contain lens-like elements from optically transparent material.

The housing and light sources according to the second aspect of the invention are preferably distinguished by the fact that the concave-mirror-like or aperture-like, optical element and/or the optically effective surface of an optical transparent filling are designed such that with a light-emitting surface of the LED-chip of up to roughly 0.3 x 0.3 mm, with a base surface of the finished housing of at the most 1.5 x 1.5 mm and a height of at the most 1.5 mm, a light exit angle of at the most ± 30° arises, or that with a light-emitting surface of the LED-chip of up to roughly 0.3 x 0.3 mm, with a base surface of the finished housing of at the most 2 mm x 2mm and a height of the finished housing of at the most 2 mm, a light exit angle of at the most ± 20° arises, or that with a light-emitting surface of the LED-chip of up to roughly 0.3 x 0.3 mm, as well as with a base surface of the finished housing (or of a unit of the light source) of at the most 4 x 4 mm and a height of at the most 4 mm, a light exit angle of at the most ± 10° arises, wherein in each case the light exit angle is defined such that outside this angle, the light intensity with respect to the brightest angular region is smaller than 50%. These specifications define - with a given refractive index of the possible optically transparent filling - the size of the aperture opening as a function of the distance to the light-emitting surface of the LED-chip and/or the angle of the mirroring surfaces to an optical axis of the LED-chip. In particular, with a length *d* of the diagonal of the light-emitting surface, a diameter *o* of the "aperture opening" (the concave-mirror-like recess at its widest, outermost location also act as such) and a distance *a* of the aperture opening to the light-emitting surface, the following results:

$$\tan(\alpha_{\max}) = (o/2 + d/2)/a = (o + d)/2a$$

Therein, α_{max} is the maximum light exit angle, i.e. $2\alpha_{max}$ is the opening angle of the light cone. This is with corresponding concave-mirror-like or approximately concave-mirror-like (for example by way of surfaces which are conical in sections) design of the reflecting surfaces.

A suitable filling of the concave-mirror-like or aperture-like optical elements with optically transparent material likewise assumes a protective function of the LED-chips and its electrical connections. The filling may either essentially completely fill out the concave-mirror-like or aperture-like optical element, or preferably has such a low thickness that it does not fully fill the concave-mirror-like or aperture-like optical element, by which means firstly the thermally conductive path through the transparent filling material is as short as possible and secondly, as the case may be, the open surface of the concave-mirror-like or aperture-like optical element is maximised.

The optically transparent, possibly material acting as a lens-like element, need not fully cure, but for example may remain permanently elastic, and also need not be very stable with regard to mechanical loading. By way of this - and without additional protective measures - one may apply materials such as transparent silicones or amorphous fluoro-polymers as for example Teflon AF of the company Dupont. These materials not only have excellent optical properties, but in an excellent manner, apart from an occurring optical effect, they also fulfil the purpose of such a filling which lies in the protection of the chip and its electrical connections from chemical environmental influences, i.e. from harmful gases such as for example oxygen or aggressive exhaust protects, from water vapour and from water. Furthermore - with a suitable selection - they may be operated at permanent temperatures of far above 200°C without becoming yellow, brittle or outgassing. Thus they permit high chip-powers which produce high chip temperatures, and this with a high life duration.

According to a preferred embodiment of the invention, the above described ideas are at least partly combined in a light source. Such a combination fulfils all requirements which lead to a housing construction which is improved in the context of the invention.

The electrical layout of the array is preferably designed such that all chips may be operated commonly or commonly in suitable sub-groups, or that the array may be cut up into sub-groups which in each case are capable of functioning on their own. One of these sub-groups may contain a single LED-chip or a plurality of LED-chips which are electrically connected to one another in series or parallel, up to very many, for example several dozen or even hundreds of LED-chips.

In the case that the LED-chip is to be electrically contacted by the carrier, which is preferably the case, it is advantageous to design the for example metallic carrier such that it provides two zones which are electrically insulated from one another, for the electrical contacting of the LED-chip

This according to one aspect of the invention may be realised for individually housed chips or chip sub-groups by way of manufacturing the metallic carrier, for example by way of punching or similar methods, in the context of a leadframe (i.e. an electrically functional carrier strip) such that the electrical zones which in the end effect are separated from one another are connected by way of additional zones and these zones ensuring the coherence are then removed in the course of the assembly when the coherence is ensured by other elements, such as a backfill of the mentioned aperture-like or concave-mirror-like element.

It is possible to design all mentioned elements of the housing in a different manner for different applications. Thus for example it is possible to realise a very small SMD-housing with a high light collimation or high heat removal for a small LED-chip. It is however also possible to design a corresponding housing for a larger power LED-chip. Furthermore, it is possible to design the metallic, leadframe-like carrier such that the arising LED-lamp may be attached over the opening of a corresponding secondary carrier element in a freely floating manner, and thus an optimal supply of air and thus an optimal cooling behaviour is achieved. Furthermore, it is also possible to design the metallic, leadframe-like carrier such that the arising LED-lamp comprises contact legs in the context of a conventional T1 or T1¾ LED-housing.

The electrical contacting may be realised according to yet another aspect of the invention in the case of a light source with LED-chips arranged in arrays, by way of constructing the carrier within the context of a flexprint - thus of a structured conductor arrangement on a for example flexible substrate - with a metal layer and an insulator layer. The metal layer is structured such that two necessary contact zones are present per region with a chip or unit of LED-chips which are arranged next to one another and which for example emit in different spectral ranges. The zone on which the chip is fastened and which ensures the first electrical contact surrounds this chip for example in an as large-surfaced manner as possible and in an as large as possible angular range. The insulator layer is opened in an as large as possible region of this metallic zone, so that an open metallic rear side arises here. The later fastening of the metallic mirror element is effected likewise directly on this metal zone. This metal zone may be thickened on one side or both sides by way of a galvanic process, for improving the functionality.

All metallic zones of the array which arise in such a manner, may but need not be firstly connected to one another by way of metallic arms. In this manner, any division into sub-groups electrically connected in series and/or parallel at a later point in time may be effected by way of disconnecting the corresponding connection arms. This separation may for example take place by way of laser or preferably by way of drilling. The first and the second contact zone however are preferably designed such that on separating a smallest functionable sub-unit which preferably only has one LED-chip or a unit of LED-chips which are arranged next to one another and which

for example emit in different spectral ranges, from the rest of the light source, they are electrically separated from one another, that they therefore only have contact to one another via connections arranged outside the carrier element region.

It is possible to design the mentioned elements of the housing differently for different applications.

Thus for example it is possible to realise LED-chip arrays with a very small housing per chip, with a high light collimation and large heat removal. It is however also possible to design arrays with corresponding housings per chip for large power LED-chips.

Embodiments of the invention are hereinafter explained by way of drawings. The Figures 1a - 3b relate to a housing for an individual LED-chip (which for example is part of an array which forms a light source), the Figures 4-8 relate to any array of LED-chips which may be cut up.

Fig. 1a shows the basic construction of a leadframe-like metallic carrier, as a three-dimensional representation of a cut-out of this.

Fig. 1b shows the basic construction of a leadframe-like metallic carrier together with the basic construction of an aperture-like or concave-mirror-like element, as a three-dimensional exploded representation

Fig. 1c shows the basic construction of a finished, housed LED-chip, in a three-dimensional representation.

Fig. 1d shows an improved basic construction of a finished, housed LED-chip, in a three-dimensional representation.

Fig. 1e in a three-dimensional representation, shows the basic construction of a leadframe-like, metallic carrier, on an auxiliary film which permits a test of the electrical connections of the LED-chip before the final housing.

Fig. 2a in a three-dimensional representation, shows the basic construction of a leadframe-like, metallic carrier with which the LED-chip is assembled above the plane of the carrier.

Fig. 2b in a three-dimensional representation, shows the basic construction of a leadframe-like, metallic carrier with which the LED-chip is seated within a flat concave-mirror-like recess.

Fig. 3a in a three-dimensional representation, shows the basic construction of a leadframe-like, metallic carrier with enlarged electrical contact surfaces to a secondary carrier.

Fig. 3b in a three-dimensional representation, shows the basic construction of a leadframe-like, metallic carrier with electrical contact surfaces to a secondary carrier which are laterally shouldered by web-like elements.

Fig. 4 shows the basic construction of a flexprint-like, metallic carrier with an LED-chip and aperture-like or concave-mirror-like elements, as a three-dimensional representation.

Figure 5 shows the basic construction of the same flexprint-like, metallic carriers with LED-chip, and aperture-like or concave-mirror-like elements, as a section.

Figure 6 shows the basic construction of a special case of the same flexprint-like, metallic carrier with LED-chip and aperture-like or concave-mirror-like elements and specific electrical connections, as a three-dimensional representation.

Figure 7 shows another basic construction of a flexprint-like metallic carrier with an LED-chip and aperture-like or concave-mirror-like elements, as a three dimensional representation.

Figure 8 shows the basic construction of a leadframe-like, striplike, metallic carrier with an LED-chip and aperture-like or concave-mirror-like elements, as a three-dimensional representation.

The principle of a metallic, leadframe-like carrier 11 which may be used as a very long tape "from the roll" is illustrated in **Figure 1a**.

The carrier is preferably manufactured of copper or of aluminium, for example by way of punching or etching.

The dashed lines 12a to 12d are the separating lines along which the carrier 11 may be cut up at a later point in time.

Evidently, two zones which are electrically independent from one another arise within the rectangle defined by the separating lines 12a to 12d, and these are a large-surfaced zone 12 and a small-surfaced zone 13, which of course may be held together by additional, electrical insulating elements at the discussed later point in time.

The two zones 12 and 13 as a rule and at least partly, are provided with at least one additional metallic layer or layer sequence 14, 15, which for example consists of Ag or Ni/Ag/Pa or whose surfaces form the actual electrical contact surfaces and which for example act as mirror surfaces with a coating over the whole surface.

In the example, the LED-chip 16 with a contact surface on its lower side is assembled directly onto the contact surface 15 of the large-surfaced part 12 of the carrier 11. The preferred method for this is soldering or possibly bonding with an adhesive which electrically and thermally is highly conductive. The second electrical contact on the upper side of the LED-chip is connected to the so-called wire bond 17 with the contact surface 14 of the zone 13.

Of course, an LED-chip which has the two electrical contacts on its upper side may also be applied. In this case, the first contact of the LED-chip 16 is connected to the contact surface 15 of the zone 12 by a further wire bond.

In **Figure 1b**, an aperture-like or concave-mirror-like element 18 is to be seen additionally to the metallic carrier outlined in Fig. 1a. This in principle is constructed in a cube-shaped manner and preferably consists of a suitable metal such as for example aluminium or steel or of a plastic which is filled with metal particles.

The manufacture of this element may for example be effected with manufacturing methods such as die-casting or MIM (metal injection moulding) or injection moulding.

The aperture-like or concave-mirror-like element has an inner surface 18a shaped in an aperture-like or concave-mirror-like manner and penetrating the whole cube. It additionally comprises a recess 18b on its lower side.

At least in the case of the application of plastic filled with metal, the optically effective inner surface 178a may be additionally mirrored with a method such as galvanising or vapour-desposition.

The arrows drawn dashed show how the aperture-like or concave-mirror-lie element 18 later comes to lie on the metallic carrier 11.

In the drawn and other preferred embodiments, the largest part of the lower surface of the aperture-like or concave-mirror-like element 18 comes into direct contact with the large-surfaced zone 12 of the metallic carrier 11. The connection between the two elements 18 and 11 is effected preferably by way of soldering or adhering with an electrically and thermally, highly conductive adhesive.

The aperture-like or concave-mirror-like inner surface 18a approximately completely surrounds the LED-chip 16. The recess 18b ensures that firstly, the wire bond 17 is not damaged and that secondly that the zone 13 with the contact surface 14 is not in direct contact with the aperture-like or concave-mirror-like element 18.

After joining together the elements 11 and 18, the inner volume 18a of the element 18 shaped in an aperture-like or concave-mirror-like manner is at least partly filled with a transparent material such as silicone or amorphous fluoro-polymer (e.g. Teflon AF). This is effected such that the recess 18b and the recess separating the two zones 12 and 13 are likewise filled. A subsequent, at least partial curing of the filling ensures a reliable coherence of the whole housing.

Figure 1c shows a finished housing which is manufactured according to the procedural manner outlined with regard to Fig. 1b and has been subsequently cut up along the lines 12 to 12b. It may be clearly seen that the aperture-like or concave-mirror-like cube 18 is in direct – notabene metallic - contact with the large-surfaced zone 12 of the metallic carrier 11 in a large surfaced manner, said carrier being electrically separated from the small-surfaced zone 13 of the metallic carrier by way of the back filling of the recess 18b with optically transparent material.

The lower sides of the zones 12 and 13 of the metallic carrier form the contact surfaces to a secondary carrier.

In place of the carrier described by way of Figures 1a ff., one may also provide a carrier element with contact surfaces which hold together from the very beginning. For this propose, a strip-like carrier which may be later cut up into sections (along lines corresponding to 12a and 12b) is provided for the LED-chip, and is constructed in the following manner.

Firstly, a for example 50 to 200 μm thick strip of a thermally and chemically stable plastic which is only a little wider that the zone 12 (e.g. 2 times 0.1 - 0.5 mm), is provided with openings which correspond to the later zones 12 and 13 in position and size. The preparation for good adhesion of metal, e.g. chemically or with plasma, is then effected. These openings are subsequently filled for example galvanically with a suitable metal, preferably with copper.

Subsequently, as the case may be, further thin metallic layers such as Ag or Ni/Ag/Pa are deposited directly.

Figure 1d shows a variant which with regard to thermal technology is improved in comparison the previously described embodiments. The outer surface of the basically cube-like body 18 is enlarged by way of ribs. Additionally, the inner surface 18a shaped in an aperture-like or concave-mirror-like manner is back filled as little as possible with an optically transparent material 19, such as silicone or Teflon AF, so that a maximal enlargement of the thermal transfer surface is achieved.

The back filling with the optically transparent material 19 is indicated here in the context of a globe-top, i.e. in the context of an approximately spherical inner lens.

Figure 1e shows one possibility of circumventing a disadvantage with regard to manufacturing technology, of the procedure outlined in Fig. 1b. This disadvantage lies in the fact that on account of the zones 12 and 13 which are still electrically connected, it is impossible to test the electrical connections of the LED-chip 16 to the contact surfaces 14 and 15 of the zones 12 and 13 respectively, and as the case may be, repair these before the complete assembly of the housing is finished. This above all, may lead to significant increased costs with mass production.

For this reason, in Fig. 1c, the metallic carrier 11 is firstly drawn onto a sufficiently thick, as inexpensive as possible, electrically non-conductive auxiliary film 20. Thereafter, the metallic carrier 11 is separated along the section lines 12c and 12d, so that the zones 12 and 13 become electrically independent. After a subsequent assembly of the LED-chip 16, the electrical connections may then be immediately controlled, and as the case may be, repaired or not used for the further assembly.

Figure 2a shows one variant of the metallic carrier 21 which is later to be unified with an aperture-like or concave-mirror-like element, with which the zone 22 is cut and reshaped such that the contact surface 25 with the LED-chip 26 lies above the actual surface 22. This then has an advantage, when the LED-chip 26 radiates a significant share of its light downwards, thus in the direction of the zone 22. The surface 22 must of course be mirrored for an optimal effect.

Figure 2b shows a further variant of the metallic carrier 21, with which the zone 22 is reshaped and cut such that the contact surface 25 with the LED-chip 26 lies within a flat, concave-mirror-like zone 28. This reshaped zone 28 at the top comprises an annular plane surface 28a on which an aperture-like or concave-mirror-like element is soldered or bonded. It further comprises a mirrored, concave-mirror-like zone 28b and an inner, plane, mirrored zone 28c which carries the contact surface 25 and the LED-chip 26. Of course, the reshaped zone 28,

as the case may be, and - as shown in Fig. 2b may be separated through by a recess separating off the zone 23.

Figure 3a shows one variant of the metallic carrier 31 which is later to be unified with an aperture-like or concave-mirror-like element, with which the two electrically separated zones 32 and 33 are enlarged to the outside, i.e. beyond the region outlined by the lines 32a to 32b, into which the aperture-like or concave-mirror-like later comes to lie, so that the lower sides of the additional surfaces 32-1 and 33-1 form an enlarged contact surface to a secondary carrier. Additionally, the surfaces 32-1 and 33-1 may be shaped such that they - at least partly - have openings 32-2 and 33-2 with which later the whole housing may be screwed on an secondary carrier and, as the case may be, contacted electrically in a direct manner.

Figure 3b shows one variant of the metallic carrier 31 which is later to be unified with an aperture-like or concave-mirror-like element, with which the two electrically separated zones 32 and 33 are extended to the outside, i.e. beyond the region outlined by the lines 32a to 32b into which the aperture-like or concave-mirror-like later comes to lie, by way of web-like elements 32-3 and 33-3, and carry additional contact surfaces 32-1 and 33-1 at the web ends. The lower sides of the additional surfaces 32-1 and 33-1 then form the contact surface to a secondary carrier which means that the region outlined by the lines 32a to 32d may, for example for optimising the heat removal, be assembled over a corresponding opening of a secondary carrier in a freely floating manner. Additionally, the surfaces 32-1 and 33-1 may be shaped such that they - at least partly - comprise openings 32-2 and 33-2 with which the complete housing may later be screwed on a secondary carrier and, as the case may be, be electrically contacted in a direct manner.

The above embodiments may be modified in some aspects. For example, one may not rule out the optical element and the carrier element being formed as one piece with the exception of a second contact surface. This also applies to the subsequent embodiments.

Firstly the construction of a flexprint-like carrier is explained in **Figure 4**, which permits a maximal transport of heat from an LED-chip to a rear side and to metallic, aperture-like or concave-mirror-like elements.

Figure 5 which is a section through the construction of Figure 4, illustrates the construction in the vertical direction.

The carrier preferably comprises at least two partially structured layers, specifically at least one metallic and one electrically insulating layer. The carrier is particularly preferably based on a commercially available, at least two-ply flexprint material, as is offered for example by the company Dupont, and for example consists of a metallic layer, here of a 35 μm thick

copper 112, 122 and of an electrically insulating layer, here a 45μm thick layer of kapton 111, 121.

The lower lying kapton layer 111, 121 is provided with openings 111b which for example by way of galvanic growth are filled with copper 113, 123 serving as a metallic heat-dissipating layer which has been grown directly on the copper layer 112, 122 of the flexprint. Preferably, this galvanically deposited copper 113, 123 is grown on so thickly, that it is somewhat thicker than the kapton layer 111, 121 and thus protrudes slightly on the lower side.

The copper layer 112, 122 is structured such that essentially two zones 112a, 122a, and 112b are present per LED-chip 115a, 125a, said zones permitting the two necessary electrical connections for the LED-chip 115a, 125a. The distance at which these zones are repeated on the flexprint carrier is for example 2.5 mm or 3.3 mm.

All zones 112a and 112b of the complete flexprint-like carrier, as shown in Figure 4, may firstly be connected amongst one another with arm-like continuations 112d, so that electrical short circuit exist everywhere in this condition. The connection arms 112d are so long and are designed in such a manner, that they may be separated at any later point in time. This may for example be effected by way of laser or preferably by way of drilling through. This dividing of the connection arms is effected specific to the customer, so that the desired groups of LED-chip connected electrically in series and/or in parallel arise.

The outlined idea with connection arms which are to be severed at a later stage - as a rule only in part - entails two significant advantages:

Firstly one only requires as many wire bonds as is absolutely required for the electrical contacting of the LED-chip, which are always very short and thus may be held in a relatively secure manner. For producing series and/or parallel groups, one requires no, relatively expensive additional wire bonds which always represent an uncertainty - in contrast to the ideas outlined in the documents WO9941785 and WO03023857.

Secondly, the flexprint-like carrier plates provided with the connection arms 112d may be manufactured in a large number and be take from storage. The later dividing up may then be effected in a very economical and a customer-specific manner in very small batch numbers up to large batch numbers, for example by way of stacking the flexprint-like carrier plates up to 50 to 100 pieces, and commonly drilling through them at the locations required for the desired configuration.

Of course, it is also possible to produce the connection arms 112d from the very beginning only such that a certain desired series/parallel configuration arises. This for example is preferable for the case in which individual housed LEDs are to arise at the end. Series/parallel connected configurations may also be effected in a manner known per se with wire bond connections between the contact zones.

In order for the wire bond 115b, 125b which leads from the second contact surface of the LED-chip 15a, 25a to the second electrical connection, i.e. the second contact zone 112b, 122b, to be as short as possible, this second contact zone 112b, 122b is provided with an arm-like continuation, which projects into the region of the first electrical connection 112a, 122a, up to the proximity of the location of the LED-chip 115a, 125a, and at its second end forms the second contact surface 112c, 122c.

For example, an approx. 30 to 50 μm thick copper layer 114, 124 is grown onto the zone 112a, for example by way of a second galvanic step, so that the surface of this copper layer 114, 124 lies higher than the contact surface 112c, 122c of the zone 112b which projects into it, and forms the first contact surface for the LED-chip 115a.

As a rule, at least partly a - not shown - additional metallic contact layer or contact layer sequence which for example consists of Ag or Ni/Au/Pa and whose surface forms the actual electrical contact and which for example acts as a mirror surface with a complete-surfaced coating, is present on the first contact zone 112a, 122a or the additional copper layer 114, 124.

In the example, the LED-chip 115a, 125a with a first contact surface on its lower side is assembled directly onto the contact surface formed here by the additional layer 114, 124. The preferred method for this is soldering and possibly bonding with an adhesive which is electrically and thermally highly conductive. The second electrical contact on the upper side of the LED-chip, with a so-called wire bond 115b, 125b, is connected to the contact surface 112c, 122c of the second contact zone 112b.

Of course, an LED-chip which has both electrical contacts on its upper side may also be applied. In this case, the first contact of the LED-chip 115a, 125a is contacted with the first contact surface 114 by a further wire bond.

The aperture-like or concave-mirror-like body 116, 126 (also called aperture-element or concave-mirror-like element) is designed such that such is present per LED-chip. Preferably, it is constructed in a completely rotationally symmetrical manner, so that it may be manufactured inexpensively in small batch numbers, for example by way of turning form the bar. For larger

batch numbers, one may also apply another method such as injection moulding or metal injection moulding (MIM).

The aperture-like or concave-mirror-like body 116, 126 is preferably metallic and amongst the metals, is of aluminium. It may however also be of a plastic which is filled with metal particles and thus highly thermally conductive.

Since the surface of the copper layer 114, 124 lies higher than the contact surface 112c, 122c of the second contact zone 112b which projects into it, the aperture-like or concave-mirror-like body 116, 126 may completely contact the first contact surface 115a without a short circuit to the second contact surface 112c existing, even if it is designed in a rotationally symmetrical manner. The body 116, 126 therefore need not be directed to the orientation of the contact zones.

The aperture-like or concave-mirror-like element 116, 126 has an inner surface 158 penetrating the whole body and shaped in an aperture-like or concave-mirror-like manner. Additionally, the element has a recess 158b on its lower side.

The optically effective inner surface 158a must additionally be mirrored with a method such as galvanising or vapour deposition, at least in the case of a plastic filled with metal.

The aperture-like or concave-mirror-like body 116, 126 is assembled directly on the first contact surface formed here by the copper addition layer 114, 124. This is preferably effected by soldering, but it may also be effected with an electrically and thermally highly conductive plastic.

If soldering is to be applied, one must of course take care that any soldering of the LED-chip being effected earlier takes place at a temperature which is higher than the subsequent soldering of the aperture-like- or concave-mirror-like body 116, 126. This is no problem if for example an Au-Sn solder is applied for soldering the LED-chip, which only melts at approx. 300°C. LED-chips which are provided with such a solder on the lower side are for example obtainable from the chip manufacturer Cree.

Preferably, the aperture-like or concave-mirror-like body 116, 126 on its lower side is designed such that on its inner side, it comprises a lip projecting downwards, which during the process of assembly comes to lie directly on the first contact surface 114, 124. This has the advantage that also light beams which exit the LED-chip horizontally or almost horizontally are reliably incident onto the mirror. The gap present to the outside, between the aperture-like or concave-mirror-like body 116, 126 and first contact surface 1124, 124 may accommodate the connection means 128 and, as the case may be, displace excess connection means to the outside.

After the competed assembly of the aperture-like or concave-mirror-like body 116, 126, this, at least partly, is provided with its own transparent filling 127 which is to protect the LED-chip 115a, 125a and the wire bond 115b, 125b from environmental influences.

A complete filling has the advantage that it may be manufactured in a simpler and less expensive manner. A filling with an as small as possible thickness has the advantages that firstly the optical path of the light through the transparent filling is as short as possible and thus the optical losses are minimised. Secondly a low thickness of the filling also ensures an improved heat removal in the sense that the thermally conductive path is short and that a part of the inner surface of the aperture-like or concave-mirror like body 116, 126 is open.

Of course, this transparent filling 127 may also contain dyes for the conversion of the light emitted by the LED-chip 115a, 125a to a different wavelength. Such dyes may either be contained in the transparent filing in a homogeneous or in an inhomogeneous distribution. With an inhomogeneous distribution, such with which the dye is present in a high concentration in the direct vicinity of the LED-chip 115a, 125a is to be preferred.

Since the aperture-like or concave-mirror-like body 116, 126 protectively surrounds the LED-chip 115a, 125a, the wire bond 115b, 125b and the filling 127, one may also use permanent-elastic materials such as silicone or amorphous Teflon as filling materials. These materials amid the transparent plastics have quite excellent properties, wherein amorphous Teflon is even superior to the silicones. They protect against water and water vapour and oxygen, are resilient to very many aggressive gases, do not outgas, do not become yellow, and all this also at permanent temperatures of over 200°C. Furthermore, thanks to the permanent elasticity, they do not transmit any mechanical stresses which could arise for example by way of different thermal coefficients of expansion, or by way of bending of the panel.

For improving the optical and thermal properties of the optically transparent material, this may for example be filled with small particles (diameter 1 μm up to 100 μm) of an inorganic, optically transparent material which has a high thermal conductivity and preferably a refractive index of > 1.8, as is the case for example with diamond and titanium oxide.

For further improving the optical properties, the optically transparent filling material may also be filled with nano-structured - smaller in diameter that the wavelength of visible light – particles of an inorganic, optically transparent material which has a high thermal conductivity and preferably a refractive index > 1.8, as this is the case for example with diamond or titanium oxide. The fact of the scattering at larger particles which is disadvantageous for many applications, is removed with such a nano-structuring.

The ideas of the Figure 4 and 5 as a sum show a construction, with which for example 116 LED-chips 115a, 125a per cm^2 are arranged in an array arrangement, wherein each LED-chip 115a, 125a has a protecting, aperture-like or concave-mirror-like body 116, 126 with a temperature-proof, protective transparent filling. It realises a customer-specific application flexibility to a great extent thanks to the connection arms which may be divided in an infinite manner at a later stage, and thanks to the ability to be cut up into infinite functionable sub-groups ensured by the flexprint-like carrier.

An unmatched temperature resistance and heat dissipation is ensured since an essentially metallic thermally conductive path leads from the LED-chip 115a, 125a to the rear side of the complete construction in a direct manner and with the shortest path (approx. 100 μm), and additionally an essentially metallic thermally conductive path with a large cross section leads to the metallic aperture-like or concave-mirror-like body 116, 126 and thus to the front side of the complete construction.

Measurements with corresponding constructions have shown that a corresponding construction may be operated over at least 2000 hours without measurable loss of brightness, even at temperatures around 100°C with LED-currents which are approx. three times the maximal permissible currents at 40°C specified by known chip- or LED-lamp manufacturers.

The construction of the Figures 4 and 5 has the characteristic that the first electrical contact surface 114 by way of the copper layer 112a of the flexprint lying thereunder, and the heat dissipation copper layer 13, reaches to the lower side of the construction, whilst the second electrical contact zone 112b is only present on the upper side. This is always advantageous if a maximum heat dissipation into any, preferably metallic body providing an assembly surface, is to be achieved. In this case, the lower sides of all heat dissipation layers 113 may be effected by way of soldering or with an electrical and thus very thermally conductive adhesive. The metallic body then serves also as one of the two necessary current supplies.

A special case of the construction of Figure 4 and 5 is sketched in **Figure 6**, with which electrical connections are present such that each individual LED-chip of a complete array may be activated individually.

For this purpose, firstly all connection arms 132d between the zones 32a and 132b are separated such that in each case only all zones 132b lying one after the other in the transverse direction of the array, i.e. lying in a column, remain electrically connected to one another. Additionally, the array on its lower side is connected to electrical conductors 137 running in the longitudinal direction such that all zones 133-132a-134 lying one after the another in the longitudinal direction, i.e. lying in a line, are electrically connected to one another.

Clearly, with an array connected in this manner, the individual LED-chips may be explained in the context of a screen pixel, with regard to the fact that a current of variable magnitude according to the desired brightness, is connected for example column for column and line for line, such that in each case a single LED-chip lights for a short time, thus for example for 10 μsec, and thus for example a variable or stationary picture with a picture frequency of for example 50 to 100 Hz may be represented.

Another construction of a flexprint-like carrier is explained in **Figure 7**, which permits a maximal thermal transport from an LED-chip to its rear side and to metallic aperture-like or concave-mirror-like elements.

In contrast to the construction of Figures 4, 5, 6, here a construction is present, with which both electrical contact surfaces necessary for the contacting of the complete array or of cut-outs of the array reach to the lower side of the array, and thus a contacting in the context of an SMD is possible. The construction is based on a carrier with preferably three layers, two metallic layers and one electrically insulating layer lying therebetween.

Preferably, the carrier is based on a commercially available, three-ply flexprint material as is offered for example by the company Dupont and which for example consists of a first layer of 35 μm thick copper 141, of a 25 μm thick layer of kapton 142 and a second layer of 35 μm thick copper 143.

The first copper layer 141 is structured such that essentially two zones 141a and 141b are present per LED-chip 145a, which permit the two necessary electrical connections for the LED-chip 145a. The distance at which this zones are repeated on the flexprint-like carrier is for example 2.5 mm or 3.3 mm.

All first and second zones 141a and 141b of the complete, flexprint-like carrier may, analogously to Figure 4, be firstly connected amongst one another with arm-like continuations 141d, or likewise certain desired series/parallel configurations may be present from the very beginning, or even no connection arms at all may exist.

The zone 141b furthermore carries a small indentation which approaches the zone 141a as far as possible and later serves as a contact zone 141c for the wire bond 145b

The zone 141a is structured such that it is firstly largely open in its inside, i.e. comprises a passage hole 141e. This opening 141e of the zone 141a corresponds to an opening 142b of the insulating kapton layer 142 lying thereon.

The second copper layer 143 is closed in the region of the opening 142b or 141e. By way of a galvanic step, with which the growth begins at the closed copper surface 143, the two openings 142 and 141e of the kapton and copper layer are filled with copper 144 serving as a heat dissipation layer, such that an electrical and thermal connection between the second copper layer 143 and the first copper layer 141 arises, and that the lower sides of the galvanic copper 144 and the first copper layer 141 essentially again form a plane.

The second copper layer 143 is structured such that it forms individual islands whose scope in shape and size corresponds essentially to that of the aperture-like or concave-mirror-like elements 146 to be set at a later stage. Furthermore, each of these "islands" has an opening 143b in the proximity of its middle.

At a later point in time, a wire bond 145b is led down to the second contact surface 141c through this opening 143b and a corresponding opening 142c in the insulating kapton layer142.

The contact zones 141b, 141c and 143 as a rule and at least partly, are provided with an additional metallic layer or layer sequence, which is not shown, and which for example consists of Ag or Ni/Au/Pa and whose surfaces form the actual electrical contact surfaces and which act as mirror surfaces for example with a coating over the whole surface.

The same considerations as to the above embodiment apply with regard to the contacting of LED contact surfaces on their upper side and possibly also on the lower side by way of soldering and/or bonding and with respect to the forming, assembly and filling of the aperture-like or concave-mirror-like body 46.

The idea of Figure 7 also in its sum shows a construction, with which an array arrangement, for example 16 LED-chips 145a are arranged per cm^2, wherein each LED-chip 145a has a protective, aperture-like or concave-mirror-like body 146 with a temperature-resistant, protective transparent filling. Thanks to the connection arms 141d which may be infinitely separated at a later stage, and thanks to the ability to be cut up into infinite functionable sub-groups ensured by the flexprint-like carrier, it realise an very high customer-specific applicational flexibility.

An unrivalled temperature resistance and heat dissipation is ensured, since an essentially metallic, thermally conductive path leads directly and over the shortest path (approx. 100 µm) from the LED-chip 145a to the rear side of the complete construction, and additionally an essentially metallic, thermally conductive path with a large cross section leads to the metallic

aperture-like or concave-mirror-like body 146, and thus to the front side of the complete construction.

Measurements with corresponding constructions have shown that a corresponding construction may be operated over at least 2000 hours without measurable loss of brightness even at temperatures around 100°C, with LED-currents which are approx. three times the maximal permissible currents at 40°C specified by known chip or LED lamp manufacturers.

The construction of Figure 7 has the characteristic that the two electrical contact surfaces 141a or 144 and 141b reach to the lower side of the construction. This is always advantageous if the array is to be cut up into individually housed LED-chips in the context of an SMD-LED lamp or into small groups of housed LED-chips, which then later - as the case may be together with electronic components - are to be deposited onto a conductor plate by way of SMD technology.

It is also advantageous if a large array of housed LED-chips are to be connected in a complex manner, for example in series and/or parallel groups which are interleaved in one another. In this case, the LED-array according to Figure 4 - with which, as the case may be, no connection arms 141d are formed, may for example be unified with a conductor plate ensuring the desired circuiting, by way of SMD technology.

Figure 8 shows the principle of the special case of a strip-like LED-array, with whose manufacture one may apply the even less expensive leadframe technology.

Firstly the principle of a metallic, leadframe-like carrier 151 is explained, which may be used as a very long tape "from the roll".

Preferably, the carrier is manufactured of copper or from aluminium by way of punching or etching.

The dashed lines 152a to 152d are the separating lines along which the carrier 151 may be cut up at a later point in time.

Within the rectangle defined by the separating lines 152a to 152d, evidently two zones which are electrical independent of one another arise, a large-surfaced zone 152 and a small-surfaced zone 153 which of course at the discussed, later point in time may be held together by additional electrically insulating elements.

The two zones 152 and 153 as a rule and at least partly are provided with at least one additional metallic layer or layer sequence, which is not shown, and which for example consists

of Ag or Ni/Au/Pa and whose surfaces form the actual electrical contact surfaces and which act as mirror surfaces for example with a coating over the whole surface.

In the example, the LED-chip 56 with a contact surface on its lower side is assembled directly onto the contact surface 155 of the large-surfaced part 152 of the carrier 151. The preferred method for this is soldering and possibly bonding with an adhesive which is electrically and thermally highly conductive. The second electrical contact on the upper side of the LED-chip, with a so-called wire bond 157, is connected to the contact surface 154 of the zone 153.

Of course, an LED-chip which has both electrical contacts on its upper side may also be applied. In this case, the first contact of the LED-chip 156 is contacted with the contact surface 155 of the zone 152 by a further wire bond.

An aperture-like or concave-mirror-like element 158 of the already described type is to be seen additionally to the metallic carrier 151. This element in principle is constructed in a cube-like manner and preferably consists of a suitable metal such as aluminium or steel for example, or of a plastic filled with metallic particles. It may of course, as has already been shown above, have an essentially rotationally symmetrical shape.

The arrows drawn dashed show how the aperture-like or concave-mirror-like element 158 later comes to lie on the metallic carrier 151.

In the shown and other embodiments, the largest part of the lower surface of the aperture-like or concave-mirror-like element 158 comes into direct contact with the large-surfaced zone 152 of the metallic carrier 151. The connection between the two elements 158 and 151 is effected preferably by way of soldering or adhering with an adhesive which is electrically and thermally highly conductive.

The aperture-like or concave-mirror-like inner surface 158a surrounds the LED-chip 156 approximately completely. The recess 158b ensures that firstly the wire bond 157 is not damaged, and that secondly the zone 153 with the contact surface 154 is not in direct contact with the aperture-like or concave-mirror-like element 158.

After joining together the elements 151 and 158, the aperture-like or concave-mirror-like shaped inner volume 158a of the element 158 is at least partly filled with a transparent material such as silicone or amorphous fluoropolymer (e.g. Teflon). This is effected such that the recess 158b and the recess separating the two zones 152 and 153 are likewise filled. A subsequent, at least partial curing of the filling ensures a reliable retention of the whole housing.

After the joining-together and a subsequent separation of the housed LED-chip 56, the lower sides of the zones 152 and 153 of the metallic carrier 151 form the contact surfaces to a secondary carrier.

The invention may be modified in some aspects. For example, one may not rule out forming the optical element and the carrier element as one piece up to a second contact surface.